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A paper presented at the 18th Annual Meeting of the American Institute of Electrical Engineers, New York, May 21st, 1901, President Hering in the Chair.

THE NEW EDISON STORAGE BATTERY.

BY ARTHUR E. KENNELLY.

I take pleasure in bringing to the notice of the INSTITUTE, this evening, a novel type of storage battery, recently invented by Mr. Edison.

It is well known that the history of the storage cell is essentially that of the lead cell discovered by Planté in 1860, in which lead peroxide is the depolarizing substance. An enormous amount of labor has, in the aggregate, been expended upon the improvement of this cell in the hands of experimentalists. As a result of that labor, the storage battery has at last become a recognized adjunct to direct-current central stations, but it has limitations that seem to withstand further attempts toward improvement. Of recent years, hardly any success has been met with in the direction of reducing its weight for a given energy-storage capacity, without detriment to endurance, and this weight is the great drawback of the storage battery in electric storage traction, and has been the principal obstacle to its advance in this direction for the past twenty years.

In practice, the storage energy per unit mass of the modern lead battery, is from four to six watt-hours per pound of battery (8.8 to 13.23 watt hours per kilogramme). Expressed in another way, a battery weighs from 124.5 to 186.5 pounds per horse-power-hour at its terminals (75.5 to 113.4 kilos per kilowatt-hour); or, if its stored energy available at terminals were all expended in gravitational work, a battery could raise its own weight through a vertical distance of from two to three miles (3.2 to 4.8 kilometres).

While it is possible to increase the energy per unit mass by making the electrodes very light, yet this is always found to be followed by a very heavy deterioration.

Many attempts have also been made to perfect storage cells of the alkaline-zincate type, but the great difficulty of depositing zinc in coherent form from the solution, as well as the lack of a depolarizer that shall be insoluble in the electrolyte, has stood in the way of this cell's success.

Mr. Edison set himself the task of finding a cell which should possess the following advantages:

1. Absence of deterioration by work.
2. Large storage capacity per unit of mass.
3. Capability of being rapidly charged and discharged.
4. Capability of withstanding careless treatment.
5. Inexpensiveness.

He believes that the cell here shown may claim these advantages in a very satisfactory degree.

The negative pole, or positive element, corresponding to the zinc of a primary cell, or the spongy lead of a secondary cell, is iron. The positive pole or negative element, corresponding to the carbon of a primary cell, or lead peroxide of a secondary cell, is a superoxide of nickel believed to have the formula NiO_2. The cell is therefore a nickel-iron cell, a name which suggests the structural material—nickel-steel. The electrolyte is potash; viz., an aqueous solution containing from 10 to 40% by weight, but preferably 20%, of potassium hydroxide, the freezing temperature of which is 20° below zero F. or –30° C.

The initial voltage of discharge after recent charge is.... 1.5 volts
The mean voltage of full discharge is approximately.... 1.1 volts
The normal discharging current rate per unit area of active element (positive or negative) is..... 60 $\frac{\text{milliamperes}}{\text{sq. inch.}}$
or..... 8.64 $\frac{\text{amperes}}{\text{sq. foot}}$
or..... 0.93 $\frac{\text{amperes}}{\text{sq. decimetre.}}$
The storage capacity of the cell per unit of total mass of the cell is..... 14 watt-hours per pound
or..... 30.85 watt-hours per kilo
Expressing the same statement in another way, the weight of battery per unit of electric energy at terminals is
53.3 lbs. per E. H. P. hour
or..... 32.4 kilos per kilowatt-hour

Or the battery gives energy at its terminals sufficient to lift its own weight through a vertical distance of approximately ....7 miles or 11.26 kilometres.
The mean normal discharging power-rate per unit mass of total cell is ..... 4 watts per lb. or 8.82 watts per kilo:
Corresponding to a normal discharge period of.... ....3½ hours
The cell may, however, be discharged at a relatively high rate, in approximately.....1 hour:
Corresponding to a discharging power rate per unit of total cell mass of.....12 watts per lb. or 26.46 watts per kilo.
Charging and discharging rates are alike. That is to say, the cell

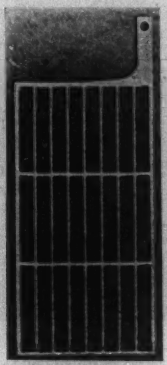

FIG. 1.—Nickel-plated steel grid for either positive or negative plate.

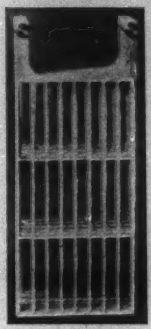

FIG. 2.—Assemblage of grids in the grouping corresponding to that of a completed cell.

may be charged at the normal rate in 3½ hours; or, it may be charged at a relatively high rate in one hour, with no apparent detriment beyond a somewhat lowered electrical charge efficiency. In other words, the cell does not appear to be injured by over-charging or discharging, and only suffers in electrical efficiency under such treatment.

The positive and negative plates are mechanically alike, and can scarcely be distinguished by the eye. They differ only in the chemical contents of their pockets. The samples here exhibited, which are intended for automobile batteries, illustrate the

construction. Each plate is formed of a comparatively thin sheet of steel, 0.024″ (0.61 mm) in thickness, in which rectangular holes are stamped, so as to leave a grid or frame somewhat resembling a window-frame. In the plate here shown, there are three rows of eight such rectangular holes or recesses, or 24 recesses in all.

Each opening or recess is filled with a pocket or shallow box containing the active material. These boxes correspond to the panes of glass in the window-frame analogy. The panes instead of being thinner than the frame, as in an actual window, are thicker than the frame, or project slightly beyond the surface of

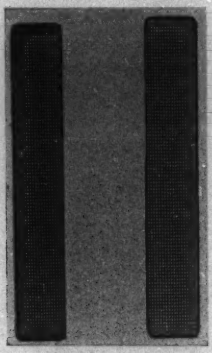

FIG. 3.—Perforated nickel-plated steel box and lid for containing the active material.

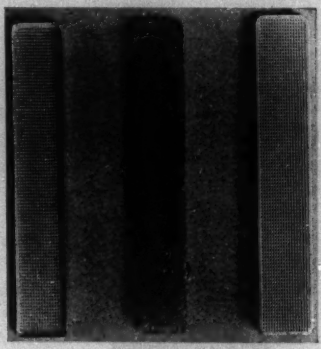

FIG. 4.—Steel box, lid and briquette of active material, ready for insertion.

the steel grid. They are perforated with numerous small holes to admit the electrolyte, but entirely conceal the contained active material from view. All that meets the eye, therefore, in any of the plates, is the steel frame, and its embedded "windows" of perforated steel.

The active material is made in the form of rectangular cakes or briquettes, and one such briquette is lodged in each pocket or "window pane" of the plate. Each of the plates shown, therefore, supports, or contains, 24 briquettes of active material, all in rigid contact with its own substance.

Each briquette is placed in a shallow, closely fitting nickel-plated box of thin perforated crucible steel, cut from a long strip

of that material 0.003″ (0.075 mm.) thick. A cover or lid of the same material is then laid over it, so that the briquette is closely enveloped by the sides and walls of its perforated steel box. The boxes are then placed in the openings or holes in the nickel-plated steel grid, and closely fit the same. The assembled plate is then placed in a hydraulic press, and subjected to a total pressure of about 100 tons. This pressure not only tightly closes the boxes, but it also forces their metal sides over the adjacent sides of the recesses in the steel grid, thus clamping the whole mass into a single solid and rigid steel plate with the hollow "window panes" full of active material. The nickel-plating of both grids and boxes aids in securing good permanent electric connections between them. The finished plate has a grid thickness of 0.024″ (0.61 mm.), and a "window" or pocket thickness of 0.1″ (2.5 mm.). This is the maximum thickness of the plate at any point, but being of steel, the plate has ample rigidity.

The positive briquettes (zincs of a primary cell) are made by mixing a finely divided compound of iron, obtained by a special chemical process, with a nearly equal volume of thin flakes of graphite. The graphite does not enter into any of the chemical actions, but increases the conductivity of the briquettes. The graphite is divided into very thin laminæ by a chemical process, and these are passed through sieves or screens so as to leave a size or area of flake that is much larger than the area of the perforation in the steel windows. The mixture is then pressed into briquettes in a mould, under a hydraulic pressure of about two tons per square inch. The briquettes have a surface area of nearly 3″ x ½″ on each face.

The negative briquettes (carbons of a primary cell) are made by similarly mixing a finely divided compound of nickel, obtained by special chemical means, with a nearly equal bulk of fine flakes of graphite, and solidifying the mixture in a mould into briquettes of the same size as above.

A suitable number of positive and negative plates are assembled together, being separated from one another only by a thin sheet of perforated hard rubber.

The assembled plates are placed in a vessel or external containing cell of sheet steel containing the potash solution, which, of course, does not attack steel. There was, however, much difficulty from the action of the potash on the soldered seams of the steel containing vessel. After many trials, how-

ever, Mr. Edison found a solder which seems to be entirely unaffected by the alkali.

In charging, the current is, of course, sent into the positive pole and its attached negative nickel-plate, through the electrolyte, and into the positive plate of the iron compound which carries the negative pole. This current deoxidizes or reduces the compound to spongy metallic iron and carries the oxygen through the film of electrolyte to the nickel compound, oxidizing it to the superoxide of nickel $Ni\ O_2$, a higher oxide than the peroxide. In other words, the charging current simply carries oxygen in

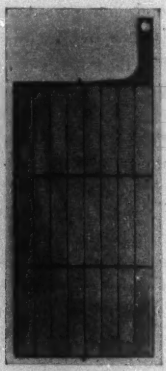

FIG. 5.—Assembled and completed single plate containing 24 briquettes of active material.

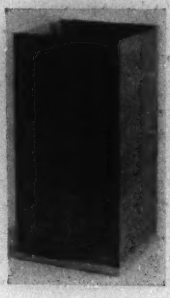

FIG. 6.—Sheet steel containing cell.

the opposite direction against the forces of chemical affinity, from the iron to the nickel, and stores the energy in the reduced iron, which is, of course, unaffected and passive in the presence of the potash solution. On discharge, the current passes from the positive pole through the external circuit to the negative pole, and its attached iron or positive plate, and then through the solution to the negative or superoxide plate. In so doing the oxygen moves back against the current and partially reduces the nickel superoxide $Ni\ O_2$, while oxidizing the spongy iron. The energy of combination of the iron and oxygen which would be developed as heat in the ordinary chemical process, is now liberated in the circuit as electrical energy.

The cell is an oxygen-lift. Charging pulls the oxygen away from the iron and delivers it temporarily to the nickel. The condition is then stable, until the circuit of the cell is completed. Discharge then allows the oxygen to fall back from the nickel to the iron by virtue of the natural affinity of iron and oxygen.

This action is very different from that which takes place in the lead storage cell. Here, neglecting complications, the action is usually regarded for practical purposes as being represented by the equation

$$PbO_2 + 2H_2SO_4 + Pb = PbSO_4 + 2H_2O + PbSO_4 + 100 \text{ watt-hours},$$

where the left-hand side represents the condition of charge and the right-hand side the condition of discharge. Here oxygen is not simply transferred in discharge from the peroxide to the spongy lead, but the solution is changed (theoretically) from an aqueous solution of sulphuric acid to plain water. Of course the discharge could not practically be carried to the point of denuding the solution of all sulphuric acid, and a surplusage of acid must be used. The equation gives a mere theoretical outline of admittedly very complex reactions. In other words, the specific gravity of the sulphuric acid solution falls during the discharge, and the solution enters into the chemical combination. Theoretically, for every 445 grammes of active material on both plates, 196 grammes of sulphuric acid are required to effect the combination, or 44% by weight of the active elements, and in practice it is usual to allow a weight of sulphuric acid nearly equal to half the weight of the elements, or about one-quarter of the total weight of the cell.

In the new Edison cell, on the other hand, the theoretical action of the potash solution is merely to provide the proper channel through which the oxygen ions may travel in one direction or the other—positive plate to negative plate in charge, and negative plate to positive plate in discharge. Consequently, the amount of solution needs only to be sufficient to fulfill mechanical requirements. It is believed that the weight of solution will in practice be only about 20% of the plate weight or about 14% of the cell weight. In fact the cell may be worked in the same manner as the so-called primary "dry-cells." Moreover, if the solution should escape, or be carried away, by gasing in charging, the only detriment seems to be the loss of active surface thereby occasioned, and it will only be necessary to fill up

the cells to the proper level with water from time to time, as evaporation or gasing may lower the level. For the same reasons the specific gravity of the electrolyte does not appreciably vary during charge and discharge.

The briquettes of active material slightly expand on receiving oxygen, and slightly contract on delivering it, that is to say, the iron briquettes contract and the nickel briquettes expand during charge, while on discharge the iron briquettes expand and the nickel briquettes contract. The level of the solution is in this way scarcely affected. The expansions and contractions of the briquettes appear to be well within the elastic limits of the spring-steel containing boxes, and consequently the electric contact is always secure. The covers or sides of the window pockets merely approach to or recede from each other slightly during charge and discharge. Fortunately, steel is the metal which possesses this mechanical elasticity in a marked degree.

The action of the charging and discharging current upon the briquettes seems to be transferred from their external surfaces inwards in a manner similar to the transfer of carbon and oxygen in the process of making malleable cast-iron in the furnace on the principle of cementation. No active material has been found to be ejected from the briquettes through the window perforations, even under deliberate overcharging and discharging. Such gas as is thereby produced makes its appearance on the external surface of the windows.

If the nickel compound had no affinity for oxygen, so that energy was neither developed nor absorbed in the deoxidation or further oxidation of that substance, then the energy would be entirely that due to the energy of combination of oxygen and iron, stated to be 79.7 watt-hours, and representing an E. M. F., theoretically obtainable, of 1.47 volts. If the combination of oxygen with the nickel compound be exothermic or energy-releasing, then the watt-hours delivered (and the E. M. F.,) will be lessened by the energy necessarily paid back to break up the combination.

If on the other hand the combination is endothermic or energy-absorbing, then the watt-hours delivered (and the E. M. F.) will be increased by the energy restored on breaking up the combination. Since the superoxide seems not to have been known hitherto, no information concerning its energy of combination is obtainable. The electromotive force of the cell seems to be so

near to that of the union of iron and oxygen as to suggest that the nickel superoxide is not far from being neutral, or that the nickel compound has but little affinity for oxygen, although the superoxide appears to be quite stable in the cell.

The new cell does not seem to be appreciably influenced by changes of temperature, and should stand a very low temperature without detriment. The electrolyte—potash—does not attack any of the ingredients of the cell, nor are any of the ingredients soluble therein. No local action occurs in the cell so far as has yet been observed, since the E. M. F. is below that necessary to decompose water.

The cell may be fully discharged to the practical zero point of E. M. F. without detriment. In fact, a cell has not only been completely discharged, but recharged in the reverse or wrong direction, and after bringing it back to its originally charged state by proper restoration of the direction of charging current, the storage capacity remained unaffected. It would seem, therefore, that the cell should be capable of withstanding much abuse.

Diagrams are appended giving the curves of discharge of experimental cells.

Fig. 7 shows a six-hour discharge curve from observations upon a small experimental Edison cell, but with the current strength increased in such proportion as to represent the delivery of a cell weighing 21 lbs. Fig. 8 shows a 3¾-hour discharge of the same cell. The outfit is approximately the same in both cases. The comparatively sudden drop in pressure or bend in the curve indicates a change in the electro-chemical action of the cell at a certain point of exhaustion of the iron plate.

Mr. Edison states that "the negative plate (nickel) either charged or discharged, can be removed from a working cell, and dried in the air for a week, without appreciably injuring it, and when the plate is finally replaced in the cell its charge is practically undiminished."

The positive (iron) plate, if similarly removed from the cell will be likewise uninjured, but it soon loses its charge by the oxidation of the spongy iron with accompanying liberation of heat and appreciable rise of temperature extending over a period of several hours. On replacing the electrode, however, in the cell, the storage capacity is unaffected on recharge.

As regards cost, Mr. Edison believes that after factory facili-

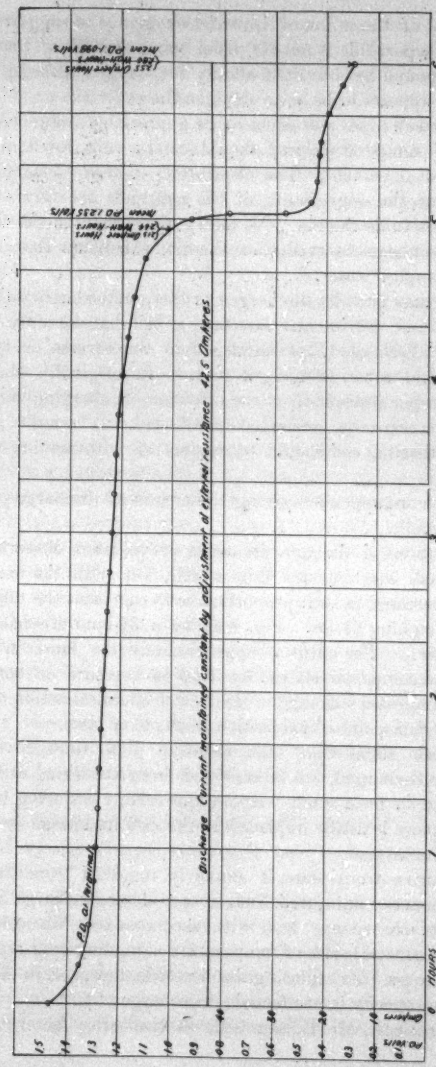

FIG. 7.—Discharge Curve of Experimental Edison Cell, referred to a cell of 21 lbs. weight. Six-hour discharge at constant current.

ties now in course of preparation have been completed, he will be able to furnish the cells at a price per kilowatt hour not greater than the prevailing price of lead cells.

Having now considered the action and properties of the cell,

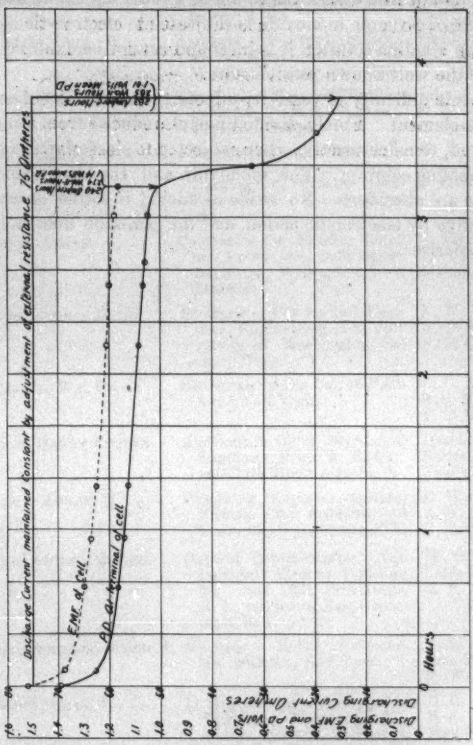
Discharging Current Limiters
Discharging EMF and PD Volts
Hours
E.M.F. of Cell
P.D. at terminals of cell
Discharge Current maintained Constant by adjustment of external resistance IS Ohms

FIG. 8.—Discharge curve of same small Experimental Edison Cell, referred to a cell of 21 lbs. weight. 3½-hour discharge at constant current.

a brief description may be given of the difficulties encountered in developing it.

The phenomenon of passivity has probably kept inventors from finding this cell in the past. Mr. Edison believes that of all the very numerous compounds of iron, and of which he has tried many hundreds, the particular compound which he prepares, is perhaps the only one capable of being used.

If the dried hydrates, or oxides of iron, native or artificial, are subjected to electrolytic reducing action in any alkaline solution, they remain inert and unaffected.

On the other hand, if finely divided iron obtained by reducing a compound of iron under the action of a reducing agent, such as hydrogen, or carbonic monoxide is subjected to electrolytic oxidation in an alkaline solution it is inert and cannot be oxidized. It assumes the well known passive state.

The same difficulty of passivity affects the use of nickel or the negative element. Finely divided nickel, reduced from a nickel compound, remains inactive when subjected to electrolytic oxygen in an alkaline solution. The monoxide and the black-oxide or peroxide are also inert. No oxide of nickel is active or can be made active by electrolytic action, and the peroxide does not act as a depolarizer.

At a Meeting of the Executive Committee, on Wednesday, January 9th, 1901, the following associate members were elected:

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BERGENTHAL, VICTOR W.	The Stanley Electric M'f'g Co., residence, 74 Wendell Ave., Pittsfield, Mass.	John F. Kelly. F. A. C. Perrine. C. C. Chesney.
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DOUBT, THOMAS EATON	Professor of Physics and Electrical Engineering, The University of Washington, Seattle, Wash.	N. W. Huggins. R. B. Owens. F. B. Crocker.
GOTSHALL, WM. C.	Electrical Vehicle Co., 46 Fifth Ave., New York.	C. O. Mailloux. Rob. McA Lloyd, T. C. Martin.
GOUGH, HARRY EUGENE	Assistant in Office Mechanical Engineers, Penn. R. R. Co., 1415 11th Street, Altoona, Pa.	Harold B. Smith. Harris J. Ryan. Fred'k Bedell.
KRUESI, AUGUST H.	Designing Engineer, General Electric Co., residence, 16 Union St., Schenectady, N.Y.	E. W. Rice, Jr. A. H. Armstrong. C. P. Steinmetz.
LISLE, ARTHUR BEYMER	General Representative, Narragansett Electric Lighting Co, Box 1223 Providence, R. I., residence, East Greenwich, R. I.	W. C. Woodward. Louis W. Downes. C. F. Wallace.
MOSCHKOWITSCH, MEERS S.	Machado & Roller, residence, 307 86th St., New York.	H. L. Holbrow. Geo. F. Sever. F. W. Roller.
SCHMIDT, CHAS. J.	In Engineering Department as Telephone Engineer, Milwaukee Electric Railway & Light Co., Construction Department, Milwaukee, Wis.	D. C. Jackson. B. J. Arnold. Max W. Zabel.
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WOOD, ARTHUR BRYANT	Assistant Electrical Engineer, The Eddy Electric Co., Windsor, Conn.	H. S. Carhart. H. E. Heath. W. R. C. Corson.

Transferred from associate to full membership.

Approved by Board of Examiners, November 12th, 1900.

LYMAN, JAMES	Assistant Engineer; Chicago Office, General Electric Co., Monadnock Building, Chicago.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

New York, January 25th, 1901.

The 150th meeting of the INSTITUTE was held this date at 12 West 31st Street, and was called to order by President Hering at 8.15 P. M.

Mr. William J. Hammer, Secretary *pro tem*, announced the election by the Executive Committee of the following associate members:

Name.	Address.	Endorsed by
BARNETT, CARL P.	Draftsman and Engineer, with S. & S. Packing Co., 1326 E. 9th St., Kansas City, Mo.	W. E. Goldsbor'gh. Edwin R. Weeks. W. N. Gladson.
BLAKEMORE, MAURICE NEVILLE	Electrical Engineer, with Westinghouse E. & M. Co., Pittsburg; residence, 306 The Colonial Bldg., Wilkinsburg, Pa.	Chas. F. Scott. W. K. Dunlap. F. L. Hutchinson.
BRANDAO, JULIO VIVEIROS, *C. E.*	Rua Barao do Flamengo 8 Rio de Janeiro, Brazil, S. A.	James Mitchell. Ralph W. Pope. W. J. Hammer.
BROWN, WARREN DAY	Electrical Engineer, the Auto-Electric Co., 61 Elm St, residence, 103 E. 39th St., New York City.	Eugene Griffin. Putnam A. Bates. Arthur Williams.
CHILD, CHARLES TRIPLER	Technical Editor "*Electrical Review*." 13 Park Row, New York City.	J. J. Carty. W. E. Goldsbor'gh. Chas. W. Price.
DAVIS, HARRY PHILLIPS	Engineer of Detail Dept., Westinghouse E. & M. Co.; residence, 827 Neville St., Pittsburg, Pa.	Chas. F. Scott. L. A. Osborne. P. A. Lange.
DOWIE, HORACE	Engineering Staff, Crocker-Wheeler Co., Ampere, N. J.	Gano S. Dunn. F. V. Henshaw. E. M. Archibald.

GILLE, HENRY JOHN	Supt. Elec. Dept., St. Paul Gas Light Co., St. Paul, Minn.	Henry Floy. G. D. Shepardson. Edward P. Burch.
HASKINS, WILLIAM EDGAR	Chief Electrician So. Wks., Am. Steel & Wire Co., 27 Whipple St., Worcester, Mass.	T. Wolcott. Harold B. Smith. Forrest R. Jones.
HOWES, ROBERT	Asst. Supt. of the Light & Power System of Washington Water Power Co., Box 1587, Spokane, Wash.	Samuel Sheldon. A. W. Chapman. H. J. Ryan.
STUART, HARVE R.,	Electrical Engineer, with W. E. & M. Co., Pittsburg; residence, 524 Wallace Ave., Wilkinsburg, Pa.	Chas. F. Scott. Jno. S. Peck. N. W. Storer.

Total 11.

THE PRESIDENT:—The first paper of this evening is by Prof. W. Elwell Goldsborough on "Air-Gap and Core Distribution." Owing to the inability of Prof. Goldsborough to be here, Dr. Sheldon has kindly consented to read an abstract of the paper.

[See page 25, January, 1901, issue.]

Discussion.

Mr. Edward P. Thompson:—This paper brings up certain points in reference to magnetic flux and touches upon cases where the armature is smooth, and where the armature is provided with slots, and will serve to explain some experiments which I happen to be acquainted with that were carried on for the purpose of improving dynamos used in telephony to prevent the whistling or the buzzing sound so often heard when dynamos are so employed, and different experimenters have worked toward getting a dynamo that would give practically as steady a current as a battery.

I would like to draw a sketch on the board to illustrate this. These experiments possess interest because the combination by which the desired kind of current is obtained is novel. It has been through the mill of the Patent Office, and attempts have been made to try to prove that is old.

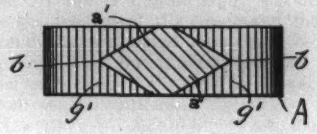

Fig. 21.

Say a' is a projection of a pole, shown in section upon the armature A, in Fig. 21. When this armature has slots, although the poles b are pointed, yet there is no steady magnetic flux whatever produced as proved by trial. The current that is generated will show its unsteady constitution by producing a buzz in the telephone. But by letting the armature have a smooth surface, and the smoother the better, and then having the conductors go across in that style as shown at g', the current that is generated is equivalent to a battery current. Of course, before the telephone came into use, currents were supposed to be perfectly steady anyway; but the telephone shows whether a current is steady or not, and by having a combination like that, the current cannot be distinguished from the battery current.

This simple form of "telephone" dynamo was invented by Arthur E. Jenney. Patent granted on appeal January 29. I have alluded to it because I thought it might be of interest to couple up a useful application with mathematical demonstrations.

Mr. E. M. Archibald:—I observe that on page 720 of the paper, Prof. Goldsborough has referred to some experiments carried on by Mr. Herdt and myself last spring. The ratio between the flux in the slot and the flux in the armature as calculated by him was 37 per cent., while the percentage obtained by

experiment was only 25. In our experiments we found, using practically the same method, that for a revolving field distributed winding machine, that this ratio was very nearly what his calculated result was, the value being 34.6 per cent. The result that we obtained was when the field was stationary, and when it is revolving the distribution is distorted slightly in the direction of rotation; but the value we were not able to exactly determine when it was revolving, because some of our apparatus broke down. But from other curves that we obtained in checking up the above, we found that the value when stationary can be taken as very nearly the same, as when the machine is running.

The next paper is by Mr. William B. Vansize, "A New Page-Printing Telegraph."

[See page 1, January, 1901, issue.]

Discussion.

The President:—This very interesting paper is now open for discussion. The improvements which may be expected in telegraphy in the new century will undoubtedly be in this direction, namely, increasing the speed, and at the same time receiving the messages in printed characters, either directly or by machine transcribing, as in this case. There are several ways in which this can be done, as stated in the paper, and it is a matter of considerable interest to observe which of these methods are going to be successful in practice.

There are a few things which, it seems to me, were not made quite clear in the paper, and which might be interesting to have Mr. Vansize describe to us more fully. One is the way in which the page printing is done from the perforated tape of the receiver. It would also be interesting to know whether the apparatus is already in commercial use, and if so, how long it has been in such use. There is another point that occurred to me while listening to the reading of the paper, and that is, whether at the receiving end, the perforated tape could be used for relaying a message, and also for duplicating; that is, for redistributing the received message by repeating it over a number of different lines from central stations.

Mr. Geo. T. Hanchett:—I should like to ask, too, what means are used to manipulate the carriage of the typewriter, that is, to shift it when a line is completed, and to move the sheet up one notch? I presume it is done by the tape, but the mechanical motion afforded by the tape is not of sufficiently powerful character, it seems to me, to move the carriage or the paper.

Mr. Vansize:—In answer to the last question I will say that up to the present time it has been customary to let the supervising operator who is necessarily at hand, shift the paper, although I suppose it might be done by a characteristic perforation in the tape.

In reply to the inquiry of the President, I would say that the tape at the receiving station has not been adapted for repetition into another circuit. The received impulses differ in essential respects from the tape that is used for transmitting.

In regard to devices for actuating the typewriter itself, you will recall the fact that there is a separate instrumentality located below the typewriter in a frame. That instrumentality consists of a series of five combs, as we call them. Each comb is characteristically slotted. Lying across those combs at right angles are a number of thin metal bars in number corresponding to the number of independent keys on the typewriter. When a series of notches are in line below any one of those bars, one of those cross-bars which is connected to the typewriter lever will drop into it. The appropriate motive power is furnished by cams, and a description of the exact mechanical arrangement would be

quite intricate. It is present there, in the machine which we exhibit. In order to get the combs aligned to cause the manipulation of any one letter, we employ a perforated tape. You can imagine the tape perforated, and you can imagine the tape having one-half inch lineal extent assigned to each character, and there may be one, two, three, four or five perforations, or one perforation may occupy any relative position between the ends of that half-inch space. The tape is fed along in front of a die-plate one-half inch at each step, and when so fed along one or more of the holes in the perforated section will register with one or more of five perforations in the die-plate. When a hole in the paper is in position and registers with one of the holes in the die-plate, the pointed end of one of the combs (before referred to) is in position, and free to pass through the perforation in the hole in the die-plate, or two or more combs may be in position to pass through registering holes in the tape and die. There is a cam which imparts to the die-plate an advance movement. As it advances the end of one or more of those combs passes through the holes in the paper, and also through the hole in the die-plate and the unperforated portion of the paper, backed up by the plate, pushes another group of the combs along with it. In that manner the notches are aligned under one or more of the bars, and when so aligned, one of the cross-bars will drop down. Up to the present time the motive power has been the human hand. There is no difficulty, however, in applying either electric or other motive power to the actuating device.

You ask the question, Mr. President, whether it was in commercial use. It has been practically adopted by the Postal Telegraph-Cable Company, and a set of instruments, having all the modern improvements which experimental work has determined upon as being desirable, is being installed, and it will then be put into use. It is not in use to-day.

THE PRESIDENT:—As I understand it, the operator at the receiving end turns a crank which operates the carriage and moves the paper along?

MR. VANSIZE:—Yes, sir.

THE PRESIDENT:—And the tape passes through, in the way shown here in this machine?

MR. VANSIZE:—Yes; in the ordinary way of hand manipulation. Then the operator, when he gets to the end of a line, stops and mechanically returns the paper and spaces, and then turns the crank for another line.

DR. F. B. HERZOG:—I would like to inquire of Mr. Vansize what is the limit of speed at which this electrical device can be operated, and also what is the particular form of typewriter that you have adopted, and the limits of its speed in transcribing from the record?

MR. VANSIZE.—The limit of speed has not been determined in typewriting devices. Of course, there must be a limit beyond

which the keys cannot vibrate. The limit of speed upon the transmitter depends somewhat upon the length of the line, of course. A number of perforators can supply a line with material for transmission; so that cannot be considered a limitation.

DR. HERZOG:—In the statements made concerning the record of the machine in the various tests, it was said that at a certain speed the signals were not received properly. Was that limit reached because the tape was perforated irregularly at that speed, or was it because the typewriting machine would not respond to the tape with sufficient speed? In other words, is the limitation due to the electrical operation of the receiving devices, or to the mechanical characteristics of the particular form of typewriter selected?

MR. VANSIZE:—The limit was due to the action of the perforator at the receiving station. Mr. Murray tells me that at the rate of 100 words a minute the punching magnet has to make 50 perforations per second.

MR. F. V. HENSHAW:—Do I understand that the limit, then, is the punching mechanism? Also, I would like to ask whether there has been any attempt made to devise a typewriter especially for this purpose, or whether you have simply utilized an existing machine? It would appear that if the limit of speed with which this system can be operated is due to the typewriting machine, that a machine could be devised in which the inertia of moving parts is very much less and much lighter, doing away with those heavy bars and keys, and thereby raising the speed perhaps.

MR. VANSIZE:—Mr. Murray has used the Bar Lock typewriter of the ordinary form that is on the market. He has not yet made any endeavor to simplify and lighten the parts of the typewriter, although he has contemplated doing so. The real limitation of speed is in the receiving perforator—the ability which it has to perforate the tape in response to the locally generated impulses; the limit of speed at which the magnet can charge and discharge and get the punch through the paper. It is a question of frequency.

MR. F. V. HENSHAW:—Have you ever tried a laminated magnet in order to increase the speed?

MR. VANSIZE:—The cores are slotted but not laminated.

DR. A. C. CREHORE:—I feel that the INSTITUTE should be congratulated upon having a paper of this character presented; I suppose partly because I am interested in the general subject. It seems to me there are many features of simplicity in this that ought to be commended. I refer to this particularly because very little is said in the paper about the transmitting arrangement. I would like to see a sample of the transmitting tape, and if possible, I would like to see the exact shape of the waves which are sent upon the line.

To do the work of cutting a perforated tape with only two

electro magnets, is a neat if not an elegant achievement. It is evident, of course, that the limit of speed must be in that perforating magnet at the receiving end. Of course, if the limit was in the typewriter, another machine could be employed and the tape divided up between the two machines, or among three or four instruments.

I see there is a reed at both the transmitting and the receiving stations, which implies that there must be approximately a synchronism between the two stations. I would like to find out how much variation and how much latitude is permitted between the receiving and transmitting stations in order to have the apparatus work successfully. Would it be possible to have a rotating motor such as is a commercial motor at present? Could the speed easily be regulated within the limits which would be necessary to operate a receiving apparatus of this nature?

Then another point is the shape of the waves or the combination of the waves that can be drawn for two characteristic letters, such as A and B, or C, perhaps; showing how they would be if you used a polarized device and the non-polarized relays in the receiving end. Of course if you refer to the alphabet as given here, it is noticeable that you have got to come down to zero current some time in order to have the magnet become released. And after you have charged the line, I particularly have in mind long distance lines where the capacity effect is very great, and if you charge the line up to its full extent, and leave it charged for three or four semi-cycles, that charge must be gotten out sufficiently in order to release the magnet, and then another charge put in. The limit of speed on a long line, it seems to me, would be reached in that way; and it would seem, and probably has been found preferable, to use the reverse current for the longer line, in order to get the charge out.

Another point that occurred to me was, how much speed has been obtained, working on a local circuit, say, in a room. The speed limit of the apparatus can not exceed on a long line what it is on a short line of that character, and that will probably depend upon the rate which the perforating magnet can operate. I should be pleased to see the action of the perforator.

The use of letters of a uniform length it seems to me is a point of great simplicity in the system, although it is not novel, of course, to this special system. I would also like to inquire whether there is any great difficulty in reading the receiving tape, providing you know the alphabet? Of course if you did not have the words separated and attempted to begin at any point, it would be very difficult, because there is no space between the letters, and you would have to try five times before you would know what you were reading.

Also, I would like to know whether the speed can be easily changed. If the reeds are set to a certain pitch would it take

you a long time to enable you to change to another pitch? Of course, in a Wheatstone apparatus it is very easy to do that, and I do not know that it is a very great point in the commercial use of the apparatus, but I know it is desirable to have a certain standard speed and keep at it. In fact, the English people would like to have a standard speed which they can use uniformly throughout the length and breadth of their island; and of course they will adopt such a speed as they can maintain upon all their lines.

Rather a general question would be in regard to usefulness of words coming out printed, like this, at the rate of 100 per minute, say, and words coming out at some higher rate, printed in Morse characters, which could be translated by an operator in the ordinary method, using a typewriter, and setting it up in print in the same way. If you could receive, say, 300 words by the dot and dash characters, such as in the Wheatstone, and only 100 in this printed way, and your lines were limited—which would you prefer? How would it be commercially determined?

MR. VANSIZE:—Answering the last question first, before it passes from my mind, I would say that that seems to be a commercial question as to whether you prefer to supply lines or to economize on the lines you have. It would seem with the facilities possessed by our principal telegraph companies, that we have lines enough, and it would be preferable to save the time of translation of the received Morse.

The attempt is made, and successfully made, to maintain unison between the *arriving current impulses* and the operation of the local impulse generator. It is not a question of unison between the transmitter and some instrument at the receiving station. It is the question of maintaining unison between the received currents, a sort of co-terminus unison. That is done by devices employing armature transit time.

In regard to the speed on a local circuit, of course we appreciate that as Dr. Crehore says, the limit of speed will undoubtedly be found, and is found in the electro-magnetic perforator used as the receiving instrument of the line. On a local circuit we have done 118 words in a very satisfactory manner, and that with the first instruments, possessing some defects, some slight features which might be changed to improve the general result. But 118 words is what we can safely calculate upon obtaining.

It is not practicable for us to read the received record from the tape. It could be done with instruments, but it cannot be done as a practical Morse operator would read the record from either a chemically prepared tape or an embossed tape.

DR. CREHORE:—Suppose you should displace one unit in your die, how would you then rectify it?

MR. VANSIZE:—We never have been confronted with that difficulty because the instrument does not permit of it. You

step your tape forward one space each time. Of course, if it fails to feed, the thing is thrown out, and I suppose you would have to go back and start over again.

DR. CREHORE:—Suppose the word furnished a sufficient landmark to begin over again, you mean, then you would go back and begin over again; but I suppose there are errors very often in the perforation?

MR. VANSIZE:—Mr. Murray says that he has an apparatus for stepping it ahead one subdivision of a letter, in case the necessity arises for doing that.

THE PRESIDENT:—In this connection I would to like to ask how you know where to begin when you feed your tape into the typewriter. You have to start with a certain fixed group of five holes; now, how do you know at which of that continuons row of holes the first group begins?

MR. VANSIZE:—You can go back to the beginning of the message. In telegraphic service the messages are all numbered, and you can start in on your tape anywhere, and you will soon find the beginning of the message, and then you can start in with a retransmission from that point.

THE PRESIDENT:—I do not think you quite understand the question that I asked; it is practically the same that Dr. Crehore asked. There is a continuous row of little guide holes in the tape, of which I understand groups of five correspond to each letter; now, in starting the typewriter, how do you know which of this regular line of holes begins the correct group? Of course the letters will be quite different, depending upon whether you begin the groups with the 1st, 6th, 11th, etc., or the 2d, 7th, 12th, or the 3d, 8th, 13th, and so on.

MR. VANSIZE:—That is true. In the case of the complication of the kind you indicate, which is entirely theoretical, we would go to the beginning of the message, which is indicated by a characteristic starting mark—take, for instance, four or five characters—we would go to that point and start again.

Referring back to Prof. Crehore's question, he asked if the speed could be easily changed. It can be easily and quickly changed. I should think five minutes would be sufficient to change its speed. You would have to change the weight on the reed at both ends if you wanted to change the speed.

The transmitting apparatus is the ordinary Wheatstone transmitter, which we have found it necessary to change to enable both of the so-called prickers to operate coincidently instead of alternately as is done in the Wheatstone system. That is because the Wheatstone cannot send a succession of the same impulses; it can only print one, three and five, while in Mr. Murray's system it is necessary to be able to transmit one, two, three, four or five, and by moving the "prickers," as the English denominate them, coincidently, that can be very easily attained.

[COMMUNICATED.]

MR. HOLLON C. SPAULDING:—The writer is much interested in the subject of page-printing telegraph instruments to be treated in the paper by Mr. Vansize to be read at the meeting of the INSTITUTE on to-morrow evening, and regrets exceedingly that he is unable to be present to take part in the verbal discussion thereon. In view, however, of the various statements and references made in the paper, it may be of interest to the members of the INSTITUTE to know that the writer has for some time past been at work on a system of telegraphic communication which bids fair to fulfill the conditions involved in a theoretically perfect system more fully than the devices described by Mr. Vansize, or even indicated by his statements as to the necessities of the case. In the writer's opinion a system of telegraphic communication to be commercially successful should comprise:

FIRST.—A key-board of the ordinary typewriter form, and not requiring the services of a skilled operator.

SECOND.—Immediate and practically instantaneous registering of the desired character at the receiving end of the line.

THIRD.—The registration of an ordinary letter or type character instead of an arbitrary combination of elements which may be translated into one or more ordinary characters.

FOURTH.—The absence of synchronous devices for sending and receiving stations, and of electrical impulses varying in strength, both of which have been found impracticable in commercial use.

In other words, it is my belief that there is a demand for, and incidentally I have succeeded in producing a type printing electro-mechanism corresponding precisely to the ordinary typewriter, except that the key-board and printing mechanism may be separated by any desired distance and connected only by wires suitable for conveying electrical impulses.

Referring to the "forms of punch" shown on page 23, I would say that the writer has had occasion to use something of this kind in another invention, and while it is true that the form of punch indicated by No. 5 is preferable to the others, this could be still further improved by making it hollow, and bevelling the teeth so that the end of the punch is practically a saw section wrapped about an imaginary axis in cylindrical form. A slot should be provided near the cutting end of the tube through which is inserted a wire which will push out the paper disks as cut from the the paper, thus keeping the cylindrical cutting end clear at all times.

[COMMUNICATED.]

MR. WILLIAM MAVER, JR.:—Whether a thing is considered simple or otherwise often depends upon the point of view. Not long

since, for instance, one of the leading electrical periodicals of London referred to a certain printing telegraph system that had been on exhibition at the Paris Fair, as of "awe inspiring complexity." Being somewhat familiar with the system referred to, I do not agree with this view of it, for, to my mind, it is comparatively simple in its mechanism and operation.

Doubtless one of the chief points of merit of the new telegraph system which has been brought to the attention of the INSTITUTE this evening by the kindness of Mr. Vansize, is its simplicity, for, if it be reliable and practicable in its operation, it must, I think be generally admitted by all who have given this subject any attention, that it is relatively quite simple in construction, and especially, as Mr. Vansize points out, as regards the alphabet employed.

Technically classified, Mr. Murray's system would probably be termed an "Automatic Page Printing Telegraph." The messages to be transmitted by it are prepared beforehand, analogously as in the case of the Wheatstone automatic system. That is, characters set to represent the letters of the message, are perforated on a strip of paper. This perforated paper is caused to send electrical pulsations over a main line, which pulsations operate apparatus at the receiving station, which, in turn, electro-mechanically perforate another strip of paper on a prearranged plan. This paper is caused to pass before a set of strips of metal that, in their operation, and, depending upon the position of the perforations in the paper, select a certain letter of a typewriter, in a manner which may perhaps be considered as somewhat similar to that in which the type of a linotype machine find their proper receptacles in the type distributing process.

The unison device employed by Mr. Murray is I think, ingenious. A somewhat analogous principle for maintaining synchronism between the transmitter and receiver was employed in the Rogers printing telegraph, one of those numerous systems to which Mr. Vansize doubtless refers, which never passed very far beyond the experimental stage. In the Rogers system, as I remember it, a wheel at the receiving station was set to run at a higher rate of speed than the transmitter. A spot of light, or a spark, actuated by the arriving signals was thrown upon the side of the revolving wheel. This spot, so long as synchronism was to be maintained, was kept within a given space on the wheel (quite a little leeway being permissible) by manually applied friction on the wheel. Mr. Murray's method is, of course, more scientific.

It may be noted that Mr. Vansize has not shown, or indicated very fully, the manner in which the messages are received on a page by the Murray system. Provision must, obviously, be made for shifting the paper at the end of each line, etc., and it would, perhaps, be interesting to know whether such provision is made at the sending or receiving end of the line. The table

of alphabets and comparisons of words which Mr. Vansize gives is of much value. Among other things, renewed attention is incidentally drawn, by this table, to the fact that the letter O, of the International Morse alphabet, employing three dashes, or 11 time units (O having a frequency of 8000), could change places to advantage with the letter K, which has a frequency of only 800, and in that alphabet employs but 2 dashes and 1 dot, or 9 time units.

The time units which Mr. Vansize has used for the dots, dashes and spaces are quite fair for machine telegraphy, such, for instance, as the Wheatstone automatic, which employs the Morse alphabet. But it is, I believe, the experience of most telegraphers that rapid Morse senders do not make the pronounced distinction between dots, dashes, and letter and word spaces that theory requires and the machine system employs. The machine system makes the Morse dash equal to 3 dots; the space between letters equal to 3 dots, and the space between words equal to, say, 6 dots. A Morse operator sending rapidly makes the dash about equal to 2 dots, the letter space equal to 2 dots, and the word space equal to 3 dots. An examination of an embossed tape from a Morse register or recorder will, I believe, show this to be quite nearly the case.

It is perhaps worth noting that the different printing telegraph systems to which Mr. Vansize refers, the Baudot, the Buckingham and the Murray, do not greatly vary as to the message or word-carrying capacity they give to a wire. The Baudot, sending four messages, practically at once, over the wire, transmits a total of about one hundred and thirty-four words per minute. The Buckingham duplexed, about one hundred and sixty, and the Murray, duplexed, it is assumed about the same. A Morse quadruplex system, worked to its full capacity, gives about one hundred and sixty words per minute. The Baudot system, while not sending as many words per minute as the printing systems, does not employ a perforated tape for transmitting.

The further progress of the Murray system will doubtless be watched with much interest.

THE PRESIDENT:—The inventor of this very ingenious and simple system is with us to-night, and I am sure we should all be much pleased to hear from him.

MR. DONALD MURRAY:—I would prefer, gentlemen, to exhibit the mechanism rather than to describe it to you, because I think Mr. Vansize has very ably dealt with the subject, and I do not think I could add anything of interest to what he has said so well. I shall very happy to show the machine to you after you have finished the discussion, and especially to call your attention to the arrangement by which the typewriter carriage is run back, as I believe one of your members inquired particularly about that feature.

There must be an operator to attend to the receiving of the

message. You cannot have a purely automatic mechanism receiving and distributing the telegrams without supervision. There must be some one in attendance to read the telegrams as they are received, and therefore, while reading the telegrams, the attendant may just as well turn a handle and run the typewriter carriage back.

I have an arrangement for stopping the printer by means of a signal at the end of each line. This break signal is put in the transmitting tape. When you are playing on the keyboard of the perforator that punches the transmitting tape, and wishing to make a break, you depress a key which inserts a break-signal in the transmitting tape. This break-signal is transmitted and recorded on the receiving tape, and by means of a clutch mechanism the break-signal stops the printer. The typewriter carriage is then run back by the attendant, and the act of running the carriage back starts the machine again. A man has to be there, anyhow, to attend to the receipt of the messages, and he can easily feed the paper into the typewriter and run the carriage back at the end of each line.

MR. GEO. T. HANCHETT:—I am not much of a telegrapher, but it seems to me that the commercial value of this machine will be subject to this condition. We have several systems which are giving satisfactory service; notably the Morse sounder and typewriter and operator. In this machine we have a more complicated typewriter and receiving instrument and also an operator. Now, there must be some gain for this additional complication

I do not know how many words it is possible for an ordinary typewriter operator to take down in a minute, but I understand that it is possible to send by the Morse system as many words a minute as the ordinary typewriter operator can take down on the machine. I do not know, as I say, how fast a typewriter can be operated, but perhaps our stenographer could tell us.

THE PRESIDENT:—We would be obliged to the stenographer if he would give us some information on that point.

The stenographer stated that seventy-five words per minute was about the highest speed of an expert typewriter operator in writing from continuous dictation.

MR. HANCHETT:—Then, if that is so, it appears that here is a difference in speed between 75 words a minute and whatever this system is capable of——

MR. MURRAY:—If you would allow me to explain. The limit of speed is not in the ability of the receiving typewriter. The receiving typewriter can get up to a speed of ninety words a minute, though that is exceptional. I have had considerable experience with typewriter operators, and I think the average speed is not much more than fifty words a minute; indeed, it is a very good operator who does that. It is the transmitter who is at fault. Transmitting by the Morse key, the average speed

is about 15 words a minute, working by the hour, and 30 words a minute is about the maximum.

MR. HANCHETT:—Then, if 15 words a minute is the average speed of the Morse operator, the gain between that and what is accomplished by this system, which is 100 words a minute, shows what the device accomplishes.

MR. MURRAY:—It is unlikely that the Morse key and sounder will ever be superseded for business requiring quick dispatch. The printing telegraph system described this evening and the others mentioned by Mr. Vansize are big high-power systems like express trains, and they are best suited for handling the mass of telegraphic business between large centers of population. I believe that in time they will each find special fields of usefulness in accordance with their particular capacities. The system described this evening is specially adapted for newspaper work, because the perforated receiving tape can be used to automatically operate a linotype or typesetting machine.

DR. CREHORE:—It is not quite clear to me yet by referring to Figure 4, where the unison diagram is given with the word "Paris," how it is made definite. For instance, take the black line of dots numbered 3 underneath; I understand that that line represents the current impulses coming over the main line. Is that so?

MR. VANSIZE:—Yes, that is right.

DR. CREHORE:—And the black represents the positive current. Then, does the white space immediately following, represent the negative current or no current?

MR. MURRAY:—Either.

DR. CREHORE:—Then would it be possible to divide, say, that first black space which covers two units in the letter "P" into two separate impulses and get the same effect if they were both in the same direction? I mean, could you divide it up in two and not necessarily have it continuous?

MR. VANSIZE:—Yes, sir.

DR. CREHORE:—Or, you could use two successive semi-signs in the same direction, could you?

MR. MURRAY:—I think that would be possible. The real trouble in using the alternating current is to get the time current intervals.

DR. CREHORE:—If the transmitting apparatus has to be as uniform in speed as the reed below vibrates, or very nearly so, how much variation would there be that variation without interrupting the successful operation of the apparatus?

MR. MURRAY:—That is a question that I could not give you any very definite information about. It will run up as high as five per cent. above the transmitted currents and it will still govern; there is no trouble about that.

THE PRESIDENT:—We have with us to-night Mr. Jones, of the Postal Telegraph-Cable Company, and we should be pleased to hear from him on this subject.

MR. FRANCIS W. JONES:—I did not come here prepared to enter into this discussion. I think the subject has been ably handled by Mr. Vansize. I think possibly the recording of messages upon the typewriter by the received perforated tape might have had a little more elucidation. The drift of the discussion is in the direction of the commercial possibilities of this system, as well as in the electrical and mechanical operation of the system itself. I have been in a position to watch the growth of this infant. The machine you see before you on the table, the combined typewriter with the actuating mechanism, was constructed in Sydney, Australia, by Mr. Murray, in a little workshop that I suppose could easily be placed on one corner of this platform, and I think the machine as it stands here, and as it has been operated, is a very great credit to him.

The system, as has been said, is a very simple one, and it is useless for me to criticize any of the theoretical defects in it because we have simply attached the wires to it between Chicago and New York, and between Boston and New York, and we have the messages here to show what it has done. So it is not for me to say it will not work, when it has worked, and when messages have come through the before-mentioned wires in very clear and nice shape.

It does not seem wise to let this discussion branch off into wild theories. The very best that Morse telegraphers can do, in a day's work, is about thirty words a minute. The simplest of all telegraph systems, outside of the telephone, if you wish to include it, is the Morse system, where a man sits with his hand on his key, his eyes steadily fixed upon the message, the words passing in through his eyes and out through his fingers over the wire into the ear of the receiving operator, and the latter printing it upon a portable printing press—a typewriter. There is no telegraph system that can transmit a message from the sender to his correspondent in so quick a time, except by telephone, as the Morse system operated in this way.

Now, the present plan is to perforate a tape by a keyboard, doing away with the skill necessary for a Morse operator to codify dots and dashes and so send over a wire. It is just simply a keyboard worked the same as the keyboard on a typewriter, and the resulting perforations in the tape are put through an ordinary Wheatstone transmitter, with the modifications that have been so clearly explained by Mr. Vansize, the prickers working in unison, or simultaneously up to the paper, and there it being determined which one shall go through the perforations. Then, at the receiving end, there is nothing but two relays in line for operating the punching and spacing local magnets, as has been explained. Now, the received tape is placed in the mechanically operated typewriter; Mr. Murray suggests that it is like a mechanical piano; you turn a crank, and it plays the tune, and that tune is the telegraphic message that has been punched at the other end of the line. As you turn this crank by hand or by motor, the

typewriter keys are mechanically actuated, the type striking upon the platen, and so the message is gotten out in page form, the same as on any typewriter. The page moves forward, and when it comes to the end of the line the attendant pushes it back to its original position, and so it goes again, the attendant watching every line to see that there are no mistakes made, thus every message is under constant surveillance, and is apt to go out to the correspondent in better shape than if a dumb machine actuated by the line currents were to grind it out automatically through a slot, because then no correction would be possible if a mistake were made in a line until after the correspondent got his telegram and sent a message back to the sending station, to say it was all pied, and to please repeat it; but this attendant at the receiving machine sees at once if anything is wrong, and immediately notifies the sending station—probably by the Morse key—(the system being quadruplexed) and the sending agent repeats, and so the message is gotten out accurately and without delay.

Another thing is, if you succeed in getting upon your line, say, 100 words perforated at the receiving end, it is not necessary to use only one machine; you can use two, or more. If one machine—as mechanical things do sometimes—gets a little out of order and won't work, you can turn to another machine which is all right, and go ahead; or, you can divide the tape up among two or more persons, if you want to print a lot at a time. That is distinctly a feature of Mr. Murray's system, that the currents coming over the line have not got to actuate a printer; the printing machine is a separate and independent machine, and stands by itself.

I am not prepared to enter into a discussion of the commercial features of this invention at all. It is to stand on its merits entirely. Those people who have their money invested, and who do the telegraph business of the country, will look the matter over carefully and determine whether it is to their interest to employ this machine or not, or to what extent they will employ it. It is certainly natural to suppose that in this new century there must come some improvement; that we cannot keep on putting up wires all the time in order to accommodate the Morse system, and the telegraph managers are watching as closely, and perhaps more closely than anybody else, to find what will serve their purposes best. They certainly do not want to put their money into wires, if, in the end, a little machine will do just as well. Some very clever systems have been devised—Mr. Delany's, and several others that I could name—but the trouble seems to be that while you can get a great deal over a wire, it takes a little time at the start, and a little time at the finish, which handicaps the business, and also that the expense of preparing the tapes and translating the tapes is so much more expensive than by the Morse system, and so much more complicated, and adds so much to the delay of the business, that neither the managers of the telegraph companies nor the public, whose

business is to be transacted, will have anything to do with such systems. That seems to be about the size of the matter, as far as I can get at it. It is not because there is any prejudice at all, for there is no reason for prejudice. The Wheatstone system came to this country in 1880, and I believe there were seven circuits put up, and I think there are not five to-day. If it had been a good thing, and had satisfied the demands of the public, and also had satisfied the managers of the companies in respect to economy, it certainly would have been used more extensively. It does a large number of words per minute, and when duplexed, it is very efficient.

THE PRESIDENT:—I understand Mr. Jones to say that the limit of speed of the Morse system is thirty words a minute for each operator, and if that is quadruplexed, it makes 120 words a minute. So that the difference between a quadruplex Morse system, and a duplex system of this kind would be the difference between 120 and 200. Am I right?

MR. JONES:—Let me explain upon what I based my figures. Between New York and Boston, and some other cities, we have a system in the Postal Telegraph-Cable Company of paying an operator so much a day for his labor. He begins work at eight o'clock in the morning and quits at five-thirty in the evening, with a certain time for luncheon. We put four of those operators on a quadruplex in New York, and there are four in Boston. Those operators get a premium on each message beyond a certain number that they handle in a day. So that they get their regular salary and in addition to that so much per message over and above the number they are expected to do for that salary. Consequently they have quite an incentive to do their very best. Of course the business is ample to furnish all they can do. Now, it has been found that an operator in New York sending to an operator in Boston during that time will do at the rate of 60 to 65 messages per hour, and they average thirty words per message. I have taken thousands of messages out of our files, not only in one year but for years past, at intervals of one, two or three years, and counted them, and they vary between twenty-nine and a fraction and thirty words a message invariably. It is a very singular thing, but that will happen any time you count a bundle of messages indiscriminately. The very highest rate of Morse transmission is about thirty words a minute. Those are the very best operators—the very flower of the flock. Now, if you take the general run of operators, where there isn't piece work, and where they are not inclined to exert themselves to such an extent, where there is no incentive for it, I should think if you got fifteen words per minute on an average, you would be doing very well, indeed.

THE PRESIDENT:—I suggest that if there is no further discussion, the meeting might formally adjourn, and we can then gather around this machine and have Mr. Murray show it to us in operation, as he has kindly offered to do.

[Adjourned.]

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

New York, February 28, 1901.

The 151st meeting of the INSTITUTE was held this date at 12 West 31st Street, and was called to order by President Hering at 8.30 P.M.

THE SECRETARY:—At the meeting of the Executive Committee this afternoon the following Associate Members were elected:

Name.	Address.	Endorsed by.
BAYLEY, GUY LYNFIELD	Assistant Manager Engineering Department, The American Trading Co., No. 28 Yokohama, Japan.	A. M. Hunt. Wynn Meredith. C. L. Cory.
BRUSH, FRED'K FARNSWORTH	Engineer in charge for Mr. F. J. Sprague, Societie Francaise Sprague, 6 Rue de Madrid, Paris, France.	Joseph Sachs. Wm. J. Hammer. Ralph W. Pope.
HOXIE, GEO. L.	Student in Electrical Engineering, Cornell University, 1192 Cascadilla Place, Ithaca, N. Y.	Fred'k Bedell. Harris J. Ryan. Edw. L. Nichols.
LEEDS, NORMAN	Electrical Engineer, Western Electric Company, 463 West St., New York, residence, Stamford, Conn.	H. F. Albright. F. A. Muschenheim. Geo. A. Hamilton.
SANVILLE, HENRY F.	Secretary and Electrical Engineer, Morris Electric Co., Splice and Terminal Co., 15 Cortlandt St., residence, 213 W. 105th St., New York.	F. B. Crocker. Max Osterberg. Max Loewenthal.
TOWNLEY, CALVERT	Manager, Boston Office Westinghouse Elec. & Mfg. Co., 53 State St., Boston, Mass.	Chas. F. Scott. L. B. Stillwell. Wm. Lisp'd Robb.

Total 6.

The following Associate Members were transferred to full Membership.

Approved by Board of Examiners, October 26th, 1900.

CLARE F. BEAMES	Chief Engineer, Compania Mexicana de Gazy Luz Electrica, City of Mexico.
JAMES A. WOTTON,	Manager Wotton Electric & Mfg. Co., Atlanta, Ga.
FREDERICK W. HADLEY,	Electrical Engineer, care of Westinghouse, Church, Kerr & Co., New York.

Approved by Board of Examiners, October 12, 1900.

STEVENS, J. FRANKLIN	President Keystone Electric Instrument Co., 9th St., and Montgomery Ave., Philadelphia, Pa.
VARLEY, RICHARD JR.	President, the Varley Duplex Magnet Co., 138 7th Street, Jersey City.
LEYDEN, HARRY RUSSELL	Mgr., Hamilton Elec. Lt. & Cataract Pr. Co., Hamilton, Ont.

THE PRESIDENT:—The paper of the evening is on "Important European Electrical and Engineering Developments at the Close of the Nineteenth Century," by Mr. William J. Hammer.

Mr. Hammer read the paper.

[See page 105, February, 1901, issue.]

COMMUNICATED BY HARRIS J. RYAN, AUGUST 18, 1899, AFTER THE ADJOURMENT OF THE BOSTON MEETING.

[This is in discussion of Prof. Goldsborough's paper, vol. xvi., p. 461, and was omitted through oversight from its proper location.]

At the World's Fair a committee of the Board of Awards in the Department of Electricity made a series of efficiency tests of the large engine dynamos there exhibited. The efficiency load curves of the generators as determined by the indicator cards and those calculated from no-load core losses, electrical data, and output observations did not agree at the higher load values. They differed in all cases from three to five per cent. A satisfactory check on the efficiency measurements at the time could not be made because of these discrepancies, which were finally traced to the variation of the core losses with the generator loads. At the time and under the circumstances no satisfactory method could be found to determine independently the core loss variations with the generator loads. The results of these tests were not published for another reason—the consent to publication could not be obtained from all the makers concerned. I have recalled this experience for the purpose of emphasizing the importance of Prof. Goldsborough's paper.

Adopted at the Annual Meeting, May 21st, 1901, and now in Force.

RALPH W. POPE,
New York, May 22d, 1901. Secretary.

CONSTITUTION.

[*Adopted May 13, 1884. Amended December 8 1885, September 27, 1892, May 15, 1894, March 16, 1896 and May 21, 1901.*]

ARTICLE I.

1. The name of this association shall be the AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

2. Its objects shall be the advancement of the theory and practice of Electrical Engineering and of the Arts and Sciences connected with the production and utilization of electricity, and the maintenance of a high professional standing among its members. Among the means to this end shall be the holding of meetings for the reading and discussion of professional papers and the publication of such papers, discussions and communications as may seem expedient.

ARTICLE II.

MEMBERSHIP.

1. The corporate members of the INSTITUTE shall be designated as Members and Associates. Members and Associates shall be equally entitled to all of the rights and privileges of the INSTITUTE, except eligibility to the offices of President and Vice President, which shall be limited to Members; and Members only shall be entitled to a diploma. There shall also be Honorary Members, who shall be entitled to all the rights and privileges of the INSTITUTE, except the right to vote for officers and hold office.

2. A Member shall have been an Associate, and at the time of his transfer to membership he shall be not less than twenty-seven years of age, and shall be:

a. A Professional Electrical Engineer; or

b. A Professor of Electrical Engineering; or

c. A person who has done important original work, of recognized value to electrical science.

3. To be eligible to membership as a professional Electrical Engineer, the applicant shall have been in the active practice of his profession for at least five years; he shall have had responsible charge of work for at least two years, and shall be qualified to design as well as direct electrical engineering works. Graduation from a School of Engineering of recognized standing shall be considered the equivalent of one year's active practice.

4. To be eligible to membership as Professor of Electrical Engineering, the applicant shall have been in responsible charge of a course of Electrical Engineering at a college or technical school of recognized standing, for a period of at least two years.

5. An Associate shall be a person who is interested in or connected with the study or application of electricity.

6. Honorary Members may be chosen from among those who have rendered acknowledged, eminent services to electrical engineering or its allied sciences.

ARTICLE III.

Admission, Transfer and Expulsion of Members.

1. Honorary Members shall be proposed in writing by at least ten Members, and may be elected only by the unanimous vote of the Board of Directors, a ballot in writing to be forwarded by Members absent from the Directors' meeting. The election of an Honorary Member shall be deemed invalid if an acceptance is not received within six months after the date of his election.

2. An application for admission to the Institute as Associate shall be made in a form prescribed by the Board of Directors, and shall refer to at least three members or associates.

3. An application for transfer from the grade of Associate to that of Member shall be made in a form prescribed by the Board of Directors, and shall embody a full record of the general technical education of the candidate, and of his professional career. It shall be signed by the applicant, and shall refer to at least five Members

by whom he is personally known. Each of these references shall be requested by the Secretary to fill out a prescribed confidential form, to be addressed to the Board of Directors. No such application for transfer shall be considered until at least five favorable replies have been received. The Board of Directors, or the Board of Examiners, in the event of failure of replies, or receipt of unfavorable replies, may call upon the applicant to furnish additional names. Should an applicant for transfer certify that he is not personally known by five members, the Board of Examiners may accept references for the deficiency to professional engineers of standing.

4. The reference to Members to whom he is personally known may be waived in case of foreign applications; but the applicant shall in that case refer to at least two professional engineers of recognized standing.

5. The Secretary shall issue at stated intervals to each Member and Associate whose address is known, a list of new applications for admission to the INSTITUTE, with the request that the Members and Associates make written communication to the Board of Directors, in case of objection to any of the candidates named. The Board of Directors shall not act upon any name until at least twenty days after the date of issue of said list.

6. All elections to Associate Membership, and transfers to grade of Membership, shall be by vote of the Board of Directors; two negative votes shall exclude a candidate.

7 The Board of Directors may refuse to elect or transfer any applicant whose character, reputation or professional conduct would make him, in the opinion of the Board of Directors, an undesirable member

8. A member of any grade in the INSTITUTE may resign his membership by a written communication to the Secretary, who shall present the same to the Board of Directors; whereupon, if all his dues or other indebtedness have been paid, his resignation shall be accepted.

9. Upon the written request of ten or more Members or Associates that, for cause stated therein, a Member or Associate of the INSTITUTE be expelled, the Board of Directors shall consider the matter, and if there appears to be sufficient reason, shall advise the accused of the charges against him. He shall then have the right to present a written defence, and to appear in person before a meeting of the Board of Directors, of which meeting he shall receive

notice at least twenty days in advance. Not less than two months after such meeting, the Board of Directors shall finally consider the case, and if in the opinion of the Board of Directors a satisfactory defence has not been made, and the accused Member has not in the meantime tendered his resignation, he shall be expelled.

ARTICLE IV.

DUES.

1. The entrance fee, payable on admission to the INSTITUTE, shall be five (5) dollars. A fee of ten (10) dollars shall be paid on transfer to the grade of Member, which shall include the fee for a diploma.

2. The annual dues shall be fifteen (15) dollars for Members and ten (10) dollars for Associates.

3. The annual dues of Members and Associates residing in foreign countries other than Canada and Mexico, shall be ten (10) and five (5) dollars, respectively.

4. Honorary Members shall be exempt from all payments.

5. Persons elected after six months of the fiscal year have expired, shall pay one-half of the amount of dues for that fiscal year.

6. A Member or Associate in good standing, by the single payment of two hundred (200) dollars in addition to his entrance fee, shall become exempt from all future payments for dues or transfer fee. All money thus paid shall be invested as a permanent fund, of which the interest only shall be subject to appropriation for current expenses.

7. A Member or Associate who has been dropped as delinquent may be reinstated by the Board of Directors upon payment of all back dues, retaining his original date of election, and shall be entitled to a complete file of the published TRANSACTIONS corresponding with said payment, provided the same are in stock; or such Member or Associate shall have the option of reelection to the same grade, and payment only of his indebtedness up to the time he was dropped from the list.

ARTICLE V.

OFFICERS.

1. The officers of the INSTITUTE shall be a President, six Vice-Presidents, twelve Managers, a Secretary and a Treasurer, who shall hold office as follows:

2. The President, the Secretary and the Treasurer for one year, the Vice-Presidents for two years, and the Managers for three years. The President, a Vice-President or a Manager shall not be eligible for immediate reelection to the same office. At each annual meeting, a President, three Vice-Presidents, four Managers, a Secretary and a Treasurer shall be elected in the manner prescribed below, whose terms of office shall commence upon the fourth Friday in September.

3. A vacancy in the office of President shall be filled by the senior Vice-President; a vacancy in the office of Vice President shall be filled by the senior Manager. Seniority between officers of same rank and date of election shall be determined by the date of their election as Associates. All other vacancies shall be filled by the Board of Directors for the unexpired term. Such succession to office or appointment by the Board of Directors shall not render an officer ineligible for immediate election to the same office.

4. No officer shall receive, directly or indirectly, any salary, compensation or emolument from the INSTITUTE, either as such officer or in any other capacity, unless authorized by a vote of a majority of the entire Board of Directors.

5. No officer shall be interested, directly or indirectly, in any contract relating to the operations conducted by the INSTITUTE, nor in any contract for furnishing supplies thereto, unless expressly authorized by the by-laws and by the unanimous vote of the Board of Directors.

6. To provide for the officers already holding office when this Constitution shall go into effect, their terms shall be considered as dating from the time of the Annual Meeting as set forth in the Constitution which this Constitution supersedes, instead of from the fourth Friday in September, as this Constitution specifies; and nothing in this Constitution shall operate to exclude from office any officer elected under the previous Constitution.

ARTICLE VI.

ELECTION OF OFFICERS.

1. During the first week in February of each year, the Secretary shall mail or deliver to each Member and Associate of the INSTITUTE residing in the United States, its territories, Canada or Mexico, a list of all Members and Associates, together with a form showing the offices to be filled at the ensuing annual election in May, and

containing the names of the incumbents and a copy of sections 1 and 2 of this article, with the request that nominations be made for the various offices to be filled. These nominations shall not be signed, and shall be enclosed in an envelope identified on the face by the name of the sender. To be considered, nominations must reach the Secretary prior to March first.

2. The Secretary shall submit to the Board of Directors a classified list of all nominations received, from which the Board of Directors shall prepare, during the month of March, a complete ticket, to be headed: "Directors' Nominees," containing the names of those whom the Board of Directors deem best suited for the offices falling vacant; provided that upon the request of two Directors at the meeting at which the "Directors' Nominees" ticket is prepared, the name of a second nominee for President shall be placed on the ticket, selected from the four names receiving the highest number of votes for President; and provided further, that the names for the office of Vice-President shall be selected with a view to maintaining a geographical distribution of the incumbents of this office. This ticket shall be printed on the same sheet with a second list, headed: "General Proposal List," containing all the eligible names proposed and the number of votes cast for each; provided that no name shall appear which shall not have received at least two per cent. of the entire number of votes cast.

3. The voting for officers shall be restricted to the names on the General Proposal List provided for in Section 2 of this Article. This sheet, together with an envelope on which shall be printed the title of the INSTITUTE, the name and address of the Secretary, and the words: "Official Voting Envelope—Enclosing a Ballot Only," shall not later than the 15th day of April, be mailed by the Secretary to every Member and Associate in good standing, together with a copy of Sections 3 and 4 of this Article; provided, that any qualified Member or Associate not having a ballot and envelopes shall be entitled to obtain them from the Secretary at any time before the ninth day of May.

4. All names voted for shall be written, printed or otherwise marked on a single ticket or ballot, which shall be enclosed in a sealed, unmarked and unidentified inner envelope of any suitable character, which shall in turn be enclosed either in the "Official Voting Envelope" (received from the Secretary), or any other envelope, marked on its face; "Non-Official Voting Envelope—Enclosing a Ballot Only." The outer envelope of either class shall be identified by the name of the sender on its face, shall be sealed,

and in order to be counted, shall reach the Secretary not later than the ninth day of May. The Secretary shall preserve, unopened, all ballots received after the ninth day of May.

5. The President at the Directors' meeting to be held in April, shall appoint, subject to the approval of the Board of Directors, five Members or Associates, not members of the Board of Directors, to constitute the Committee of Tellers; should this Directors' meeting not be held, the President shall appoint this Committee by letter to the Secretary, who shall notify the members thereof.

6. Any Member or Associate who shall deliver to the Secretary on or before the ninth day of May, a written petition signed by at least twenty Members or Associates, stating their desire that he be a member of the Committee of Tellers, shall also be a member of that Committee; provided that the aforesaid signatures shall not have appeared on another similar petition.

7. The Committee of Tellers shall meet at the office of the INSTITUTE as soon after the ninth day of May as possible, and shall receive, unopened, all ballots from the Secretary, who shall also make to it a written report of the number of ballots received on and before and after the ninth day of May It shall forthwith proceed, in secret, to count the vote, and shall prepare and sign a report of the results of the vote, which shall be sealed, and shall remain in the possession of the Chairman of the Committee, who shall hand this report to the presiding officer at the ensuing annual meeting. The presiding officer shall then cause this report to be read, and shall declare duly elected the eligible persons receiving the greatest number of votes for the respective offices.

ARTICLE VII.

MANAGEMENT.

1. The affairs of the INSTITUTE shall be managed by a Board of Directors under this Constitution and the general provisions of the laws under which it is incorporated. The Board of Directors shall consist of the officers of the INSTITUTE and the two junior Past-Presidents.

2. The Board of Directors shall have such powers and duties as are prescribed by statute for a Board of Directors.

3. The Board of Directors shall direct the investment and care of the funds of the INSTITUTE, shall make appropriations for

specific purposes, shall pass upon all applications for admission or for transfer, shall act upon all questions of expulsion of members, shall appoint all employees and fix their salaries, and in general shall direct the business of the INSTITUTE, either itself or through the officers and committees.

4. The Board of Directors shall prepare and adopt a series of by-laws which shall govern its procedure and that of its committees, under this Constitution. Such by-laws shall be adopted or may be amended by a two-thirds vote of a quorum of the Board of Directors; provided, that the text of a proposed by-law or amendment shall be furnished to each member of the Board of Directors at least ten days before the meeting at which a vote of the same will be taken.

5. The President shall have general supervision of the affairs of the INSTITUTE, under the direction of the Board of Directors. He shall preside at the meetings of the INSTITUTE and of the Board of Directors at which he may be present, and shall be ex-officio member of all committees. He shall deliver an address at the Annual Convention. The Vice-Presidents, or in their absence, the Managers, in order of seniority, shall preside at meetings of the INSTITUTE and the Board of Directors in the absence of the President, and shall discharge his duties in case of a vacancy in the office. The President shall, at the meeting of the Board of Directors to be held on the fourth Friday in September, appoint the following Standing Committees: A Board of Examiners of five members; a Library Committee of five members; a Committee on Papers of five members; an Editing Committee of three members, a Committee on Finance of three members. He may also appoint temporary committees from time to time. The members of the Finance Committee shall all be members of the Board of Directors. All other standing committees shall include at least one member of the Board of Directors. All Members of the Board of Examiners shall be full members of the INSTITUTE.

6. The Secretary shall receive all moneys, and deposit them in the name of the INSTITUTE, reporting such deposit to the Treasurer, who shall receipt for the same. The Treasurer and the Secretary shall invest such funds as may be ordered by the Board of Directors. They shall also pay bills when audited by the Committee on Finance and approved by the Board of Directors. The Treasurer shall make an annual report and such other reports as may be prescribed.

7. The Secretary shall be, under the direction of the President and the Board of Directors, the Executive Officer of the INSTITUTE.

He shall attend all meetings of the INSTITUTE and of the Board of Directors. He shall prepare the business for them, and record the proceedings thereof; he shall collect and deposit, subject to the order of the Treasurer, all moneys due the INSTITUTE. He shall personally certify the accuracy of bills or vouchers on which money is to be paid, and shall draw and countersign all checks, and these shall be signed by the Treasurer when such drafts are known to him to be proper and duly authorized by the Committee on Finance, and in accordance with warrants executed by the Secretary. He shall have charge of the books and accounts of the INSTITUTE, and shall furnish monthly to the Board of Directors a statement of receipts and expenditures and monthly balances. He shall present annually to the Board of Directors a balance sheet, and from time to time shall furnish such statements as may be required. He shall conduct the correspondence of the INSTITUTE, and keep full records. He shall be in responsible charge, under the President, the Board of Directors, and the Library Committee, of all the property of the INSTITUTE. He shall be responsible for the work of all employees of the INSTITUTE. He shall perform such other duties as may be assigned to him. His entire time must be devoted to the affairs of the INSTITUTE, unless otherwise authorized by the Board of Directors. He shall be paid a salary to be fixed by the vote of a majority of the entire Board of Directors.

8. The Board of Directors may, if deemed expedient, appoint assistants to the Secretary; one of these may hold the title of Assistant Secretary, who shall be under his immediate direction and shall aid him in all matters.

9. The Board of Directors may delegate any or all of its powers to an Executive Committee of seven members, consisting of the President, the Secretary, and the Treasurer, ex-officio, and four other members of the Board of Directors, which committee shall conduct the affairs of the Board of Directors between its meetings.

10. All committees shall be directly responsible to the Board of Directors, and shall act under its directions. The Board of Directors may, at any time, at its own discretion, remove any or all members of the committees and appoint others. The terms of the members of all standing and temporary committees shall terminate on the fourth Friday in September of each year, when the incoming President shall reconstitute the membership of all standing committees, and of such temporary committees as may have further duties to perform.

11. The reports or actions of all Committees shall be addressed to the Secretary, and shall be by him referred to the Board of Directors

12. *The Committee on Finance* shall have direct supervision of the financial affairs of the INSTITUTE. It may employ an expert accountant to assist in auditing the accounts. It shall approve all bills before payment, and shall make recommendations to the Board of Directors as to the investment of moneys, and upon all specific appropriations. No payments other than routine office expenses shall be made by the Secretary or Treasurer except upon the authorization of the Committee on Finance.

13. *The Library Committee* shall have general supervision of the Library and the rooms of the INSTITUTE, and the property therein. The Secretary shall be responsible to the Library Committee for his care of the property of the INSTITUTE. The Committee shall make recommendations with reference to books, and shall direct expenditures for books or other articles of permanent value, of such sums as may be appropriated for these purposes.

14. *The Committee on Papers* shall have general supervision of the papers to be presented to the INSTITUTE at its meetings, and of the discussions thereon. This Committee shall have the responsibility of collecting papers. It shall not accept papers from non-members without special authorization from the Board of Directors.

15. *The Editing Committee* shall edit all discussions of the papers presented. It shall be the duty of this Committee to limit as far as possible the amount of matter to be printed in the discussions. The printed discussions shall preferably be put in the third person. This Committee shall decide all questions regarding the publication of papers, discussions and communications.

16. *The Board of Examiners.* All applications for membership or for transfer that may be received by the Secretary shall be referred by him to the Board of Examiners, who shall pass upon the qualifications of the various applicants and shall report their recommendations to the Board of Directors, who shall pass upon the recommendations of the Board of Examiners.

17. The Board of Directors may, at its discretion, appoint Local Honorary Secretaries to represent the INSTITUTE in various parts of the world.

18. The following Members shall constitute a quorum of the Board of Directors:

For all business prescribed by statute for a Board of Directors—Twelve Members.

For Expulsion of Members—Fifteen Members.

For all other business—Five Members.

19. The "vote of the Board of Directors" shall in all cases be the vote of a majority of the Members thereof present when the quorum required for the particular occasion is present.

ARTICLE VIII.

MEETINGS.

1. The Annual Meeting of the INSTITUTE shall be held on the third Tuesday of May, when a report of the proceedings of the INSTITUTE for the past fiscal year shall be furnished by the Board of Directors. This report shall be verified by the President, Treasurer and Secretary and a majority of the officers. It shall show: The whole amount of real and personal property owned, where located, where and how invested; the amount and nature of the property acquired during the last fiscal year and the manner of its acquisition; the amount applied, appropriated or expended during the year, and the purposes, objects or persons to or for which such applications, appropriations or expenditures have been made; the names and places of residence of persons who have been admitted to Membership in the INSTITUTE during such year; and all other facts bearing upon the status of the INSTITUTE. This report shall be filed with the records of the INSTITUTE and an abstract thereof entered in the minutes of the proceedings of the Annual Meeting. The reports of all officers shall be presented at the Annual Meeting, and the vote for officers for the ensuing year shall then be announced. Any other business may be brought before this meeting.

2. There shall also be held an Annual Convention of the INSTITUTE at some time after the Annual Meeting and before the first of December following, for the presentation and discussion of professional papers, and for the transaction of such other business as may be brought before it. The time and place of such Convention shall be fixed by the Board of Directors.

3. Other meetings of the INSTITUTE may be held at such time and places as the Board of Directors shall select, at which no business affecting the organization or policy of the INSTITUTE shall be transacted. Notice of all meetings shall be sent by mail, or otherwise, to all Members and Associates, at least ten days in advance.

4. Every question affecting the organization or policy of the INSTITUTE which shall come before any meeting of the INSTITUTE shall be decided, unless otherwise provided by this Constitution, by the vote of a majority of a quorum.

ARTICLE IX.

STATE AND DISTRICT ORGANIZATIONS.

1. In each State or Territory of the United States in which there are fifty or more Members and Associates, the Board of Directors may authorize the formation of a State organization, for the purpose of more effectively carrying out the objects of the INSTITUTE.

2. The resident Members and Associates thus organized in any State shall have the privilege of being represented at the Annual Convention by one delegate to each fifty members. Such delegates shall be nominated by the resident Members and Associates of each State, by selecting names from the membership in the State, a list of which shall be forwarded by the Secretary, who shall also prepare and distribute the necesssary circulars for that purpose. The appointment of delegates shall be made by the Board of Directors in conformity with the expressed wish of the members. The Board of Directors shall also appoint alternate delegates, who shall serve in the absence of any delegate.

3. Official delegates thus appointed will be required to attend the Annual Convention, and shall be entitled to receive from the Treasury a sum of money sufficient to cover the cost of their railroad fare. They may cast as many votes as they shall hold proxies from their constituents upon any question brought before the Annual Convention.

4. The appointment as delegate shall not debar the incumbent from appointment or election to any other office in the INSTITUTE.

5. The Members and Associates of a State or Territory not entitled to a delegate may, upon request to the Board of Directors, be authorized to join with the Members and Associates of a contiguous State or States, and form a District, which, for the purpose of this Article, shall be considered as being one State, but shall be called a District, taking its name from the State within that District having the largest membership.

6. The Dominion of Canada and the Republic of Mexico shall

each be considered as States, under the provisions of this Article.

7. Any State or Territory having a less number than fifty members may be represented by a delegate upon request to the Board of Directors, but such delegate shall not be entitled to receive from the Treasury of the INSTITUTE any portion of his expenses.

ARTICLE X.

GENERAL.

1. A quorum of the INSTITUTE shall consist of one-tenth in number of the total number of Members and Associates, residing in the United States and its territories, in Canada and in Mexico, as printed in the list provided for by Section 1, Article VI., issued each year, prior to the Annual Meeting

2. Every Member or Associate entitled to vote at any meeting may so vote by proxy. Every proxy shall be executed in duplicate in writing by the Member or Associate himself, or by his duly authorized attorney, and one copy thereof filed with the Secretary before the date on which it is to be voted. No proxy shall be valid after the expiration of eleven (11) months from the date of its execution, unless the Member or Associate executing it shall have specified therein the length of time it is to continue in force, which shall be for some limited period. Every proxy shall be revocable at the pleasure of the person executing it.

3. For the purpose of electing officers, proxy voting shall be practiced only as provided in Article VI., and the Committee of Tellers therein named shall be considered a proxy Committee for the definite purpose stated.

4. The fiscal year of the INSTITUTE shall terminate with the thirtieth day of April.

ARTICLE XI.

AMENDMENTS.

1. Proposals to amend this Constitution shall be made in writing to the Board of Directors, and signed by at least twenty-five Members or Associates, and shall reach the Secretary not later than February first; the Board of Directors shall consider such proposals, and if in its opinion they are in accordance with

the laws under which the INSTITUTE is organized, shall order the Secretary to send out a letter ballot upon such proposals. Votes, to be considered, shall be received not later than the ninth day of May. The Secretary shall refer these votes unopened to the Committee of Tellers, which shall count such votes and make a sealed report to the Board of Directors. This report shall be read at the Annual Meeting. An affirmative vote of a majority of the qualified Members and Associates shall be necessary to secure the adoption of an amendment.

2. Amendments so adopted shall take effect twenty days after their adoption; provided, that the officers of the INSTITUTE at the time any amendments become effective shall continue in office until the next fourth Friday in September.

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